Worksheet 1: Where on Earth am I?

Identify the countries of Europe. The borders are indicated as grey lines. Can you name the capitals of each country?

Worksheet 2: Where on Earth am I?

Task 1: Lost in No-man's land

Materials:

- Worksheet 2
- Compasses (drawing tool)
- Pencil
- Ruler (at least 20 cm)
- Calculator

You were abducted by aliens and taken on a ride across the solar system. On your return, you were dropped off somewhere in Europe. You have no idea where you are, but luckily you have your GPS receiver with you that should guide you to a place from where you can receive help or return home.

But … oh no … the receiver is broken. Instead of showing your location on Earth, it only displays the signal travel time of four receiving satellite signals. You will have to do it all by yourself.

The time the signals take to get to you are given in milliseconds (1000 ms = 1 s).

Radio signals are transmitted with the speed of light, so you only have to use the constant value of that speed (c = 299792458 m/s) to convert the time into a distance.

Since the clock of the receiver is not perfectly correct, the time on the display can be off from the true value. But you can deal with that later. With the map you find in your pocket and the working calculator function of the GPS receiver, you should be able to get along.

Satellite	Signal travel time (ms)		Correction (ms)	Distance (km)		Distance on map (cm)	
	measured	corrected	meas-corr	measured	corrected	measured	corrected
Sat 1	6.49						
Sat 2	12.68						
Sat 3	4.64						
Sat 4	11.87						
		Average:					

What is the scale of the map?

Try to determine the scale of the map as precisely as possible. How many kilometres in real distances correspond to how many millimetres on the map?

How far away are the satellites?

Convert the signal travel times of each of the four satellites into a distance on the map. Remember that the signal travels at a speed of 299792.458 km/s. Add the number to the table above.

What is your location?

Now that you have determined the distances between your location and the satellites, you can use your compasses to draw for each satellite, how far the signals have come. Begin with satellite no. 1. You position must be somewhere on the circle or arc drawn by the compasses. Which are the possible countries of your location? Allow for some uncertainty in determining the length of the signal path.

Continue with the other satellites. What do you notice concerning your likely position after adding each of the satellites?

What are the possible countries of your current position?

The correct position must be somewhere inside the area determined above.

Option 1: Simple solution

Estimate the centre of that area.

Option 2: Advanced solution

The common area is surrounded by four arcs. Determine the bisectors for each of them. Then, connect the opposing bisectors with lines. This results in two crossing lines whose intersection can be defined as the centre of mass. It is a good approximation of the true location.

In which country are you?

Correcting the clock

You notice that the final point of your location is a bit off of the distances you derived from the signal travel times provided in the table. What is the reason for this?

Measure the true distance from your location to each of the four satellites on the map and convert them into real distances using the map scale. Enter the values in the table.

Convert the distances into signal travel times using the constant speed of light and enter the values in the table.

Calculate the difference between the times provided and the ones derived from the interpolation. Add them to the table.

Finally, calculate the average of those four values. You simply have to add them up and divide by the number of values, i.e. four. This is the correction to be applied to the GPS receiver clock to get the correct signal travel times.